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CASE REPORT

ADVANCED

CLINICAL CASE

Long-Term Outcome of the First Completely Leadless Cardiac Resynchronization Therapy in the United States

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ABSTRACT

Completely leadless cardiac resynchronization therapy is feasible with the combination of Micra AV pacemaker (Medtronic Inc) and WiSE-CRT (EBR Inc) systems. Several reports have highlighted this combination in Europe. This case report presents a 1- year follow-up the first reported concomitant use of the leadless systems in the United States. (**Level of Difficulty: Advanced.**) (J Am Coll Cardiol Case Rep 2023;24:102020) © 2023 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

HISTORY OF PRESENTATION

An 81-year-old man on hemodialysis for end-stage renal disease with hypertension and left bundle branch block (LBBB) was evaluated for new onset systolic heart failure NYHA functional class III, American College of Cardiology/American Heart Association stage C. Transthoracic echocardiogram revealed a new decline in left ventricular ejection fraction (LVEF) from 50% to 55% a few months prior to 35% to 40% (Video 1). The patient underwent an invasive coronary angiogram that showed mild non-obstructive disease and ventriculogram reporting LVEF of 25% to 30%. He was optimized medically with angiotensin receptor blockers but could not tolerate β-blocker due to baseline bradycardia with first-degree atrioventricular (AV) block, intermittent short pauses, and second-degree type II AV block on an event monitor. Due to continued NYHA functional class III symptoms on maximally tolerated goal-directed medical therapy, he was deemed a candidate for cardiac resynchronization therapy (CRT). Conventional biventricular pacing posed a challenge in this patient due to left-sided arteriovenous dialysis

LEARNING OBJECTIVES

- To understand the feasibility of delivering totally leadless biventricular pacing and demonstrate how the system is implanted.
- To understand the potential complications of conventional and leadless CRT systems.
- To showcase that a leadless CRT apparatus could be considered for biventricular pacing in patients considered high risk for conventional CRT systems.

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The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

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ABBREVIATIONS AND ACRONYMS

AV = atrioventricular

CRT = cardiac resynchronization therapy

LBBB = left bundle-branch block

LVEF = left ventricular ejection fraction

fistula, right-sided subclavian vein stenosis due to prior right-sided port placement, and increased risk of infection due to prior history of bacteremia. Therefore, Institutional Review Board and U.S. Food and Drug Administration approval for compassionate implantation of Micra (Medtronic Inc) in the right ventricle and WiSE-CRT (Wireless Stimulation Endocardially for Cardiac Resynchronization Therapy) (EBR Inc) leadless pacemaker in the LV was sought and obtained.

PAST MEDICAL HISTORY

In addition to nonischemic cardiomyopathy, end-stage renal disease, and LBBB, the patient had a history of type 1 insulin-dependent diabetes mellitus, pancreatic cancer in remission (he underwent Whipple procedure and chemotherapy 8 years prior), and bladder cancer in remission.

DIFFERENTIAL DIAGNOSIS

The etiology of nonischemic cardiomyopathy was suspected to be due to LBBB with QRS width of 188 milliseconds (Figure 1). The other differential diagnoses considered for his cardiomyopathy were familial, chemotherapy-induced, restrictive, inflammatory, infiltrative, or idiopathic dilated cardiomyopathy.

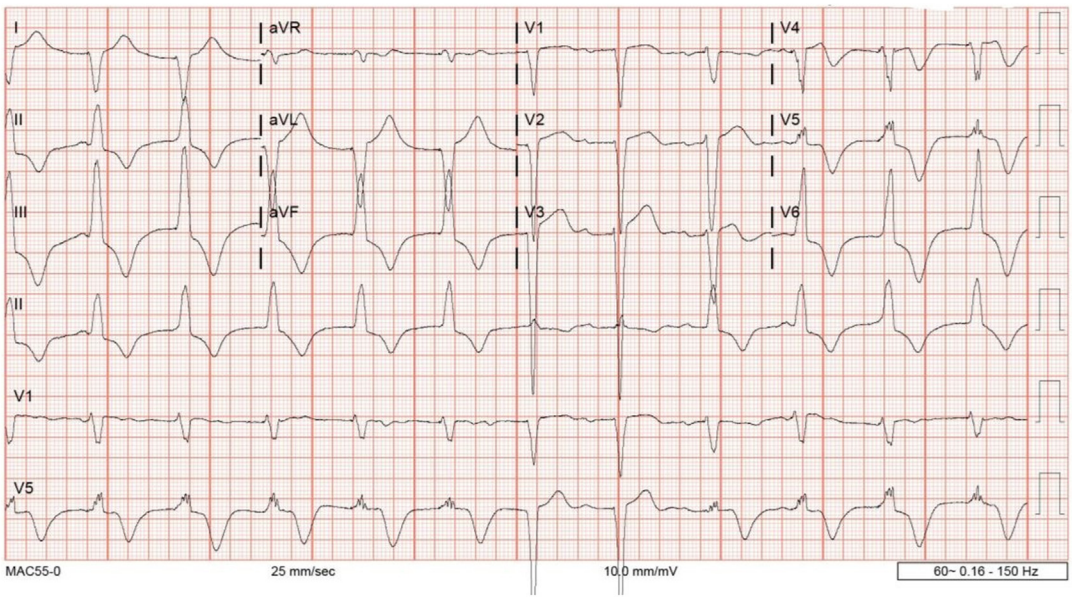
INVESTIGATIONS

Echocardiogram and left ventriculogram revealed marked reduction in EF. Electrocardiogram showed chronic LBBB and first-degree AV block.

MANAGEMENT

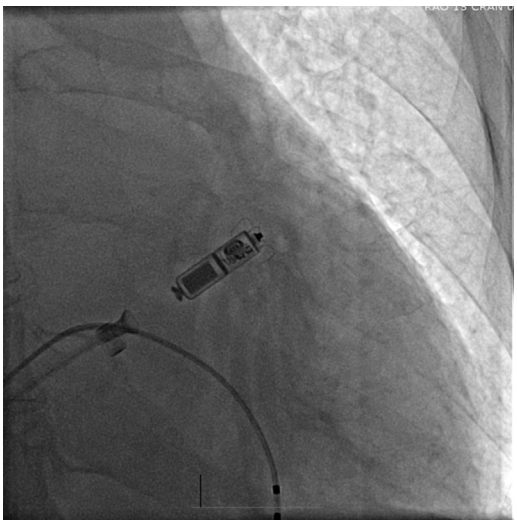
The patient was brought to the electrophysiology suite in a fasting state. The procedure was split over 2 days, with the first day involving the uncomplicated

FIGURE 1 Electrocardiogram



Electrocardiogram performed revealing left bundle branch block and concurrent first-degree atrioventricular block.

FIGURE 2 **Micra Atrioventricular Placement**



Contrasted right ventriculogram revealing adequate placement of Micra atrioventricular leadless pacemaker.

placement of a Micra AV leadless pacemaker within the right ventricular septum (**Figure 2**). Subsequently, the WiSE-CRT battery and transmitter were implanted, with fluoroscopic landmarks guiding access for pulse generator placement. A 6-cm left lateral incision was made over the sixth rib pocket in the anterior axillary line, with the subsequent ultrasound-guided placement of the intercostal transmitter between the fourth and fifth rib spaces. This was followed by mid-axillary pocket formation with adequate lead tunneling and anchoring of the generator within the pocket. All incisions were appropriately sutured and closed, and the patient tolerated the first day's procedure well.

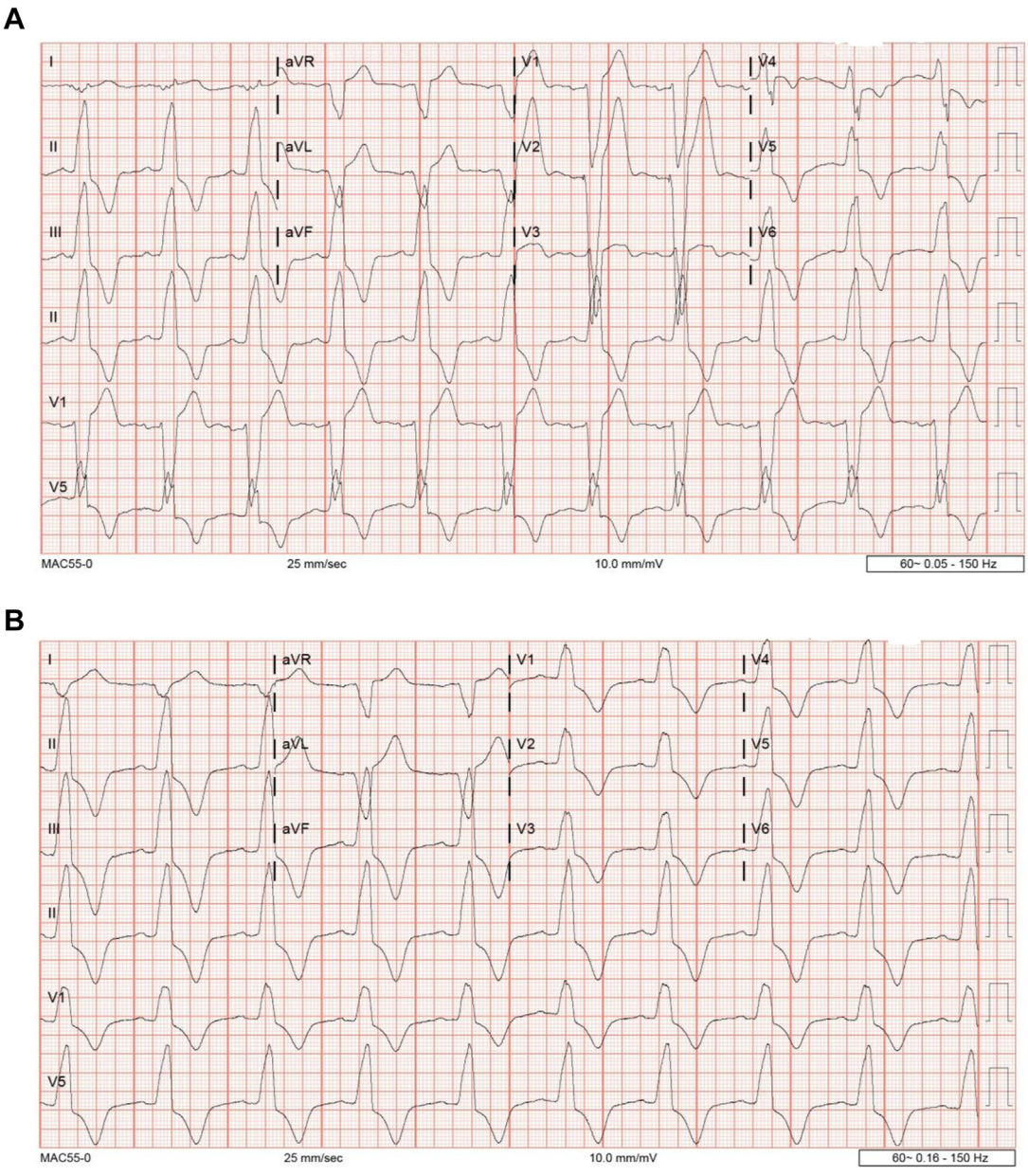
On day 2, the patient was brought back to the lab in a fasting state and sterile preparation of bilateral femoral access sites occurred. Via left femoral-venous access, pigtail catheter delivery system of the electrode followed via 12-F sheath inserted in the right femoral vein. The transseptal approach was used, and the electrode was introduced in the LV. Multiple sites around the LV lateral wall had to be tested for an appropriate site for insertion. Eventually, suitable sensing and thresholds in the anterolateral region were obtained. Multiple contrast injections were performed to confirm electrode anchoring. The electrode immediately dislodged after being detached from the delivery system. Despite multiple attempts to snare it, it migrated to a small branch of the left external iliac artery. After multiple failed attempts at snaring the device, the branch was coiled to prevent delayed perforation or bleeding. The patient was discharged home in stable condition with Micra and Wise-CRT battery transmitter; however, successful placement of the LV electrode was not completed. The symptoms of heart failure persisted on follow-up. Subsequent electrocardiogram revealed widening QRS width to 216 milliseconds (**Figure 3A**). After extensive discussion of the risks and benefits of various approaches, the patient still preferred a leadless pacemaker system. The patient was brought again to the electrophysiology lab 3 months after the initial implantation. We chose the retrograde aortic approach due to difficulties experienced with the prior transseptal approach. A 12-F sheath was inserted in the right femoral artery. The electrode was introduced in the LV. Suitable sensing and threshold in the lateral region were easily obtained. The contrast injections were performed in 2 orthogonal views to confirm anchoring.

After confirming that the electrode was anchored, the device was successfully detached from the delivery system (**Figure 4**). The final position of the implant was at the basal lateral region of the LV. The site-specific electrical delay defined as the intrinsic interval between the Q-wave on the electrocardiogram and LV sensing delay was 110 milliseconds. Post anchor, pacing threshold was 1.6 V at the pulse width of 0.5 milliseconds. The patient was discharged home the next day in stable condition. The follow-up 3-month and 1-year echocardiograms revealed sustained improvement in EF at 60% to 65% (Video 2). At 3-month follow-up, pacemaker interrogation revealed an output of 6 V at a pulse width of 1.7 milliseconds and at the 1-year follow-up the output was 5 V at 0.9 milliseconds. The patient was noted to be 100% WiSE-CRT biventricularly paced. He had significantly improved heart failure symptoms with an NYHA functional class improvement from class III to II.

DISCUSSION

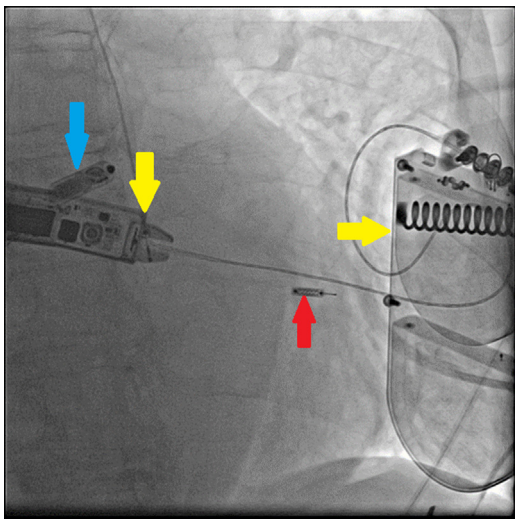
CRT has been proven to improve heart failure symptoms and LVEF.[1] However, it may not be feasible due to reasons such as prior pocket infection, lack of vascular access, or absence of a feasible coronary sinus branch. CRT could also be considered high risk in some scenarios, such as poor kidney function and potential for bleeding or vascular access complications. The potential contraindications to receive CRT affect up to 8%-10% of those patients deemed clinically eligible.[1] Patients with end-stage renal disease also have a higher risk of device-related infections. The leadless pacemaker has a lower infection risk,

FIGURE 3 Electrocardiogram Comparisons



Electrocardiogram obtained after placement of Micra right ventricular pacemaker alone (A, top), compared to electrocardiogram obtained after implantation of WiSE-CRT left ventricular electrode (B, bottom) unveiling reduced QRS duration.

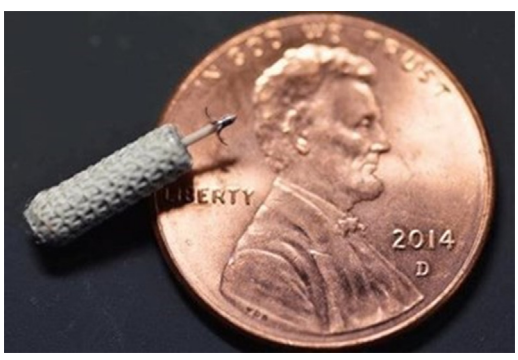
FIGURE 4 WiSE-CRT Deployment



This illustrates the WiSE-CRT left ventricular electrode (red arrow) with respective battery and transmitter (yellow arrows) with Micra atrioventricular pacemaker (blue arrow) in left anterior oblique projection.

potentially due to a smaller surface area for bacteria to seed.[2] The electrode has a much smaller surface area than Micra and could provide a similar decrease in infection risk during cardiac resynchronization. With the advent of leadless pacemaker therapies, a broader cohort of patients can reap the benefits of resynchronization. The apparatus involves a miniature electrode (Figure 5), a subcutaneous battery placed within the mid-axillary line, and an ultrasound transmitter placed anteriorly to this in the fifth or sixth intercostal space. The technology uses ultrasound beams from the transmitter, which are converted to electrical impulses by the LV electrode.[3] Combining the WiSE-CRT LV electrode and Micra right ventricular pacemaker, biventricular pacing was technically feasible and achievable in a large retrospective multicentric observational study conducted in Europe.[4] In the SELECT-LV (Safety and Performance of Electrodes Implanted in the Left Ventricle) study,[3] the risk of electrode embolization was ~3%. With the improvement in device technology, implantation tools, and operator experience, we expect the safety of this therapy continues to improve. In addition to a potential decrease in device-related infections, leadless pacemakers could also prevent lead-related complications such as lead dislodgements, fractures, valvular impingement, and subclavian vein occlusions. These features make leadless pacemakers desirable in young and active patients. Our report demonstrates the first reported application of this uniquely versatile option of CRT use within the United States.

FIGURE 5 WiSE-CRT Left Ventricular Electrode



The size of electrode is akin to a grain of rice.

FOLLOW-UP

The patient tolerated the procedure well and had improvement in heart failure symptoms since device implant more than 1 year ago. He had no recurrent heart failure-related hospitalizations and remained in NYHA functional class II status. The follow-up electrocardiogram demonstrated a reduction in QRS duration, and transthoracic echocardiogram showed improvement in LVEF to 60% to 65% with leadless CRT.

CONCLUSIONS

Herein, we present a 1-year follow-up of the first-in-man implantation of completely leadless CRT in the United States, using the WiSE-CRT LV electrode and Micra AV right ventricular pacemaker.

However, to further validate and support the use of completely leadless CRT systems, there is a need for a multicenter randomized clinical trial.

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The authors have reported that they have no relationships relevant to the contents of this paper to disclose.

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KEY WORDS biventricular pacing, cardiac resynchronization therapy, endocardial left ventricular pacing, leadless pacemaker, WiSE CRT system

APPENDIX For supplemental videos, please see the online version of this paper.